NOWCAST for the Next Generation Navy

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LONG-TERM GOALS

This project is one coordinated component of a larger effort to address specific operational decisions that are affected by meteorology and oceanography (METOC) processes. Our goal is to develop technology for a high-resolution weather data fusion (NOWCAST) system capable of blending an ensemble of highly perishable, on-scene environmental data together in the context of operational situational awareness to provide a consistent, integrated, web-enabled picture of the current, real-time METOC impacts both in the target area and within the battlegroup. This system will benefit the warfighter by providing a common environmental situational awareness capability that can be accessed directly over the network by decision makers whenever they need to evaluate their missions for environmental dependencies. Initially, the situational awareness of weather hazard information is primarily intended to support naval aviation in time critical/sensitive strike missions, but in the future the capability may be extended to improve safety, navigation, ship self defense, weaponeering, and other operational areas impacted by the environment. The NOWCAST system, data, and products will be owned, operated, maintained, and quality assured by the METOC office.

OBJECTIVES

The specific objectives of this project within the larger effort are to design and develop the prototype web-enabled NOWCAST data fusion system; to invent weather impact products utilizing a wide variety of data sources, both conventional and "through-the-sensor", including development of innovative data acquisition and processing software; and to obtain end-user buy-in through a series of high-level briefings and an Integrated Product Team (IPT) process. The IPT process is designed to ensure that the products developed for NOWCAST meet the warfighter's decision-making needs, that the NOWCAST architecture fits within the overall Navy web-enabled, net-centric, FORCENet vision, and that the METOC office can be responsible for NOWCAST operations and maintenance.

APPROACH

To meet the challenge of utilizing METOC data available at asynoptic times collected by forward-deployed units, NRL has developed the Coupled Ocean/Atmosphere Mesoscale Prediction System – On-Scene (COAMPS-OS™). COAMPS-OS™ has been significantly enhanced to support an integrated NOWCAST software component that includes interfaces to the COAMPS™ gridded data fields and conventional observation data, to the METOC FMQ-17 (shore) and SMQ-11 (shipboard)

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satellite data processing systems for satellite data, and to a NOAA data feed for NEXRAD level II and level III radar data as a precursor to DoD radar data. When available, NOWCAST can also use data from non-traditional sources focused around the battlegroup and target areas. For example, AEGIS SPY-1 Tactical Environmental Processor (TEP) and other tactical radars of opportunity can provide weather radar data around the battlegroup and unmanned aerial vehicles (UAV) may provide a rich set of target area weather observations. To use these unconventional data in real-time requires us to adapt and develop machine intelligent feature detection and artificial intelligence (AI) data fusion technology to create an automatic environmental data fusion engine. In addition, NOWCAST uses established web-based product dissemination and display technology to overcome fleet firewall policy limitations and minimize end-user training issues. The NOWCAST software application is configurable to allow the warfighter users to tailor their results to their specific operational requirements.

Another principal effort in this project is devoted to the development of high-level support and end-user buy-in to NOWCAST. To facilitate this interaction, a series of high-level briefings and meetings to senior Navy decision makers in the aviation, surface warfare, and METOC communities have been on going to expose the concept of NOWCAST and to generate support. This year, we proposed to partner with the Naval Strike and Air Warfare Center (NSAWC) and the METOC Detachment at Fallon in a Rapid Transition Proposal (RTP) to create a shore test and development site for NOWCAST to provide enhanced weather support to strike warfare. Although not yet funded, NSAWC reaction to the proposal was favorable and sponsorship is being pursued. We view the success of this project to be directly related to acceptance by the end-users. Without a feedback mechanism between the S&T process and the end-users, it is possible to be scientifically and technically correct, but produce results that are not useful. We have had three IPT meetings for NOWCAST, focused on interaction between the war fighting, METOC, and S&T communities.

Another key element of our approach is to leverage other projects at NRL and at other agencies. The NRL Base project completed this year after adapting components of the University of Oklahoma's ARPS Data Assimilation System (ADAS) to NOWCAST. The ONR Shipboard Data Assimilation System/Doppler Radar project (N0001403WX20576) has supported NOWCAST with development of both automatic product verification technology and techniques to fuse model, satellite, and radar data to create accurate high-resolution descriptions of local cloud and wind fields. In a related area, NRL has completed a major Ceiling and Visibility (C&V) technology development funded by the FAA, NASA, and Navy (N096), to provide improved C&V NOWCAST products.

WORK COMPLETED

A prototype web-enabled NOWCAST system was designed, developed, and demonstrated at NRL Monterey in FY00. The prototype system leverages technology developed for the NRL Atmospheric Variational Data Assimilation System (NAVDAS) for conventional data quality control and accesses data through the operational Tactical Environmental Database System (TEDS).

The effort for FY01 was focused on developing the technology to acquire and process new data types. In cooperation with the NRL Base and ONR projects described above, a real-time data interface and processing capability for level III NEXRAD radar data was developed. The radar processing software was transitioned to FNMOC as an early deliverable. A C&V algorithm using fuzzy logic techniques developed by the National Center for Atmospheric Research (NCAR) was adapted and implemented in NOWCAST to produce ceiling height and visibility products every 15 minutes. The ADAS three-

dimensional cloud analysis from the University of Oklahoma was adapted and implemented in NOWCAST and used to compute volume cloud elements every hour.

In FY02 the NOWCAST user interface was completely redesigned and recoded to overcome problems with the original prototype that limited user functionality and caused unreliable performance. Several new features were also developed for NOWCAST. An analysis of TEP radar data collected during a Joint Task Force Exercise (JTFX) was also completed; however, the data contained a number of artifacts and clutter that had to be manually removed. The automated quality control and processing of mobile radar data remains a scientific challenge and is being addressed in a new start.

The focus for FY03 was on developing the capability to process, fuse and display level II radar data from individual stations, similar to how we envision accessing, processing, and displaying data from DoD radars in the future, and on developing the technology to integrate lightning data processing into the system. NEXRAD data in real time is provided by the CRAFT project (Collaborative Radar Acquisition Field Test), a joint effort by the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma, the Oklahoma State Regents for Higher Education, Unidata, and the University of Washington. Through the NOWCAST project NRL is a contributing member of CRAFT. This year NOWCAST technology and algorithms were adapted to the LINUX operating system and the primary processing was moved from UNIX (Sun) to personal computer hardware, significantly reducing the expected transition costs for the system in the future.

Figure 1 is an example of the NOWCAST user interface showing an integrated weather display consisting of the current single station radial wind data for the Miami NEXRAD, two Velocity Azimuth Display (VAD) wind profiles – one for Miami and the other for Tampa Bay, lightning data, and METAR surface observations. The user-selectable option to overlay a height-dependent product, for example wind vectors, is also available. Three-dimensional winds have been added to NOWCAST to support aircraft operations and are also being applied to automatically update chemical/biological dispersion assessments through support from the Joint Science and Technology Panel for Chemical and Biological Defense (JSTPCBD).

Additionally, this year a series of NOWCAST briefings were conducted or provided to NAVAIR, Oceanographer of the Navy (N096), JSTPCBD Information Systems Technology Business Area Manager, Commander, Naval Meteorology and Oceanography Command (CNMOC), Prototype Regional Forecast Hub project, SPAWAR PMW 150, Naval Postgraduate School (NPS), Institute for Defense Analysis (IDA), Director, National Center for Environmental Prediction (NCEP) Modeling Center, National Polar-orbiting Operational Environmental Satellite System (NPOESS) System Program Director, Fleet Numerical Meteorology and Oceanography Center (FNMOC), Commander, Naval Strike and Air Warfare Center (NSAWC), and at the 2003 Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) and FNMOC South West Asia workshops.

RESULTS

The enhanced NOWCAST system developed this year now fuses a wider variety of data types; supports more mission impact areas, and handles a larger number of concurrent users than the previous version. Radar data has been assimilated into high-resolution wind products that provide impacts for chemical biological dispersion modeling, aircraft operations, and naval gunfire support. The cost reducing transition to less expensive and faster personal computer hardware provides a closer to real-time update, faster response and more satisfying user experience.

In coordination with the 6.2 NRL Base project, the developmental NOWCAST system was cycled every hour and we learned that the ADAS 3D cloud analysis consistently improves upon the COAMPS forecast background conditions. In terms of what the end user sees for verification, NOWCAST provides a simple cloud confidence score that showed 92% (ADAS) vs. 80% (27 km COAMPS background forecast).

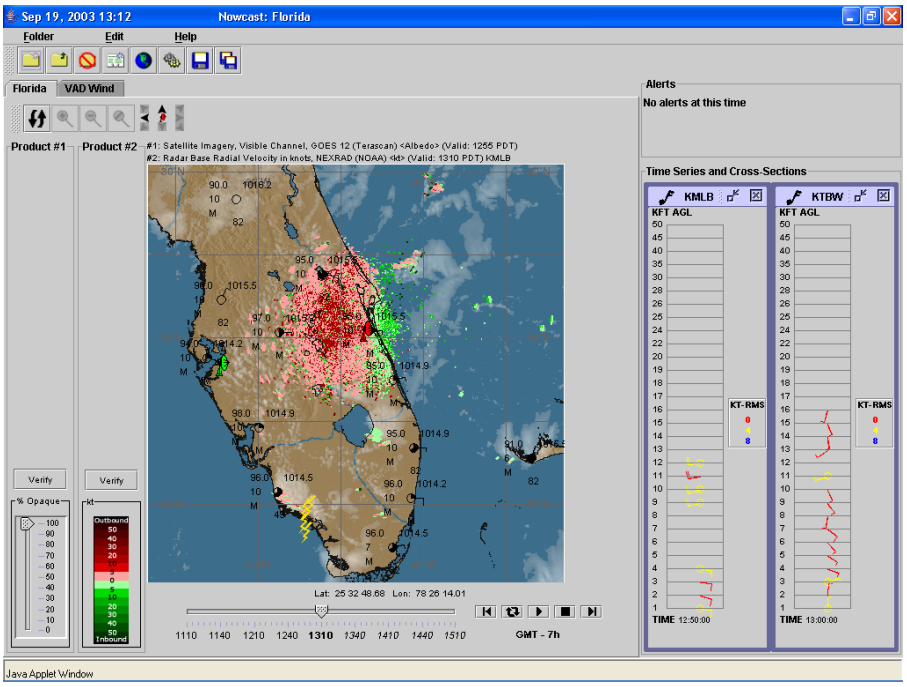

Figure 1. The NOWCAST user interface showing a map of Florida overlaid with single station radar radial wind data (Miami NEXRAD), satellite data, lightning data, surface station observation, and the two panels on the right show the concurrent radar wind profiles from the Miami and Tampa Bay NEXRADs. The products update automatically while displayed.

The interaction with the warfighters has reinforced their priorities for data fusion and decision-enabling products in the target areas, enroute, and in the carrier launch and recovery areas. We find a continuing need for NOWCAST to supplement existing METOC forecast assets with an automated capability to continuously assimilate and fuse observations from all sources including radar and UAV "through-the-sensor" observations. NOWCAST also needs to include intuitive quality control features so that the system is easy to use, operate, maintain, and monitor, and the system needs to be designed to minimize training requirements as greater stress is applied to METOC manning at sea. NOWCAST needs to interface to the Naval Fires Network (NFN) and other C^2 architectures, such as FORCENet, to help realize the benefits of net-centric warfare and 4-D battlespace awareness.

IMPACT/APPLICATIONS

NOWCAST is the focus of a telescoping strategy to provide environmental products tailored to the decision-making needs of the warfighter, from global scales down to tactical scales in both time and space. NOWCAST also represents a paradigm shift from periodic products that are briefed and interpreted by METOC personnel to nearly continuous products that are easily accessible over the web, automatically updated, and tailored for interpretation directly by the warfighter. NOWCAST enhances

the role of METOC support by supplementing the existing forecast capability with continuous, automated, short-term (less than 2 hours) decision-enabling products, thus freeing the forecaster to concentrate on the longer-range projections for planning and evaluation purposes. Figure 2 is an example of using NOWCAST to monitor severe weather associated with Hurricane Isabel during landfall south of the naval facilities at Norfolk, VA.

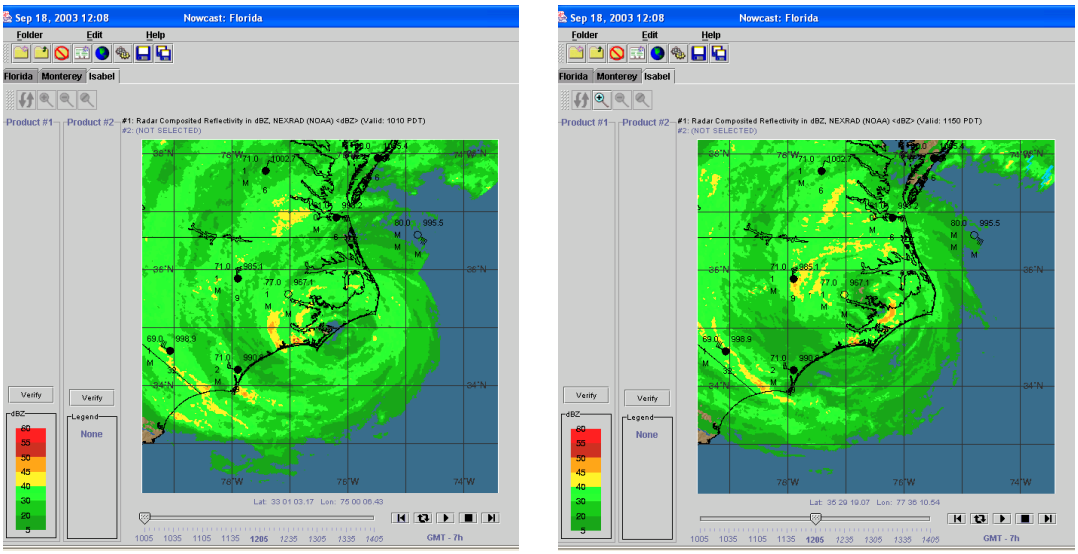

Figure 2. Two screenshots of the NOWCAST user display while monitoring the landfall of Hurricane Isabel on 18 Sept. 2003. The left panel shows the position and storm structure (radar reflectivity) at 1305 EDT and the right panel shows the structure and position at 1505 EDT.

TRANSITIONS

An early transition in FY01 was a stand-alone radar capability implemented at FNMOC.

RELATED PROJECTS

In addition to the ONR Shipboard Data Assimilation System/Doppler Radar (N0001403WX20576) project described above, the NRL Base Optimum Use of DOD Radar in Battlespace Environmental Prediction project, the ONR SPY-1 TEP project, and a similar SPAWAR Systems Center project using the SPS-48 radar are important to NOWCAST for weather radar technology at sea. The National Weather Radar Testbed (NWRT) at the National Severe Storms Laboratory (NSSL) will be a critical source of radar data processing and quality control technology. Automated chemical and biological dispersion technology is being adapted to NOWCAST under JSTPCBD sponsorship.

PUBLICATIONS

Strahl, J., D. Geiszler, J. Cook, P. Harasti, G. Love, L. Phegley, T. Tsui, Q. Zhao, F. Franco, M. Frost, R. Mantri, D. Martinez, S. Wells, and J. McCarthy, 2003: Nowcast for the Next Generation Navy: Recent Progress in Naval Nowcast Technology. 2003 BACIMO, Monterey, CA.

Zhao, Q., J. Cook, L. Phegley, K. Sashegyi, Q. Xu, P. Harasti, and M. Frost, 2003: A High-Resolution Radar Data Assimilation System at the Naval Research Laboratory. 2003 BACIMO, Monterey, CA.